



RANGE RESOURCE INVENTORY SURVEY:
A PROGRESS REPORT

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RANGE RESOURCE INVENTORY SURVEY

A Progress Report

By

John L. Retzer

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RANGE RESOURCE INVENTORY SURVEY

A PROGRESS REPORT OF RANGE-SOILS RELATIONSHIP STUDIES FOR 1946

INTRODUCTION

A study was begun in the summer of 1946 on the Pike National Forest to determine the relationships between soils, slopes and erosion, and range condition. The primary objective was to develop a method of strengthening range cover surveys by including an evaluation of the physical make-up. A consideration of all the important factors involved--range condition, soils, slopes, erosion, etc.--should form a better basis for management adjustments than a consideration of range condition alone as has been done in the past.

The range survey is primarily an evaluation of vegetative composition, density, vigor, etc. Since vegetation is subject to constant change it follows that the survey results can reasonably be expected to be out of date in a few years. The primary value of the range survey is that it furnishes a base on which to make current adjustments in livestock numbers. The survey carries little information as to the site-potential for natural recovery, the rate of recovery, the reseeding possibilities, or the actual erosion hazard of the site as compared to other sites. Neither does the survey attempt to determine the highest use-potential of the site. That is, is the site or landscape primarily suited for range, for timber, or for watershed purposes?

This study is based on the premise that the value of present range surveys will be increased, made more permanent, and have a higher degree of uniformity between survey areas by including as a part of the survey an evaluation of the factors of soils, slope, and erosion. The survey will then be in fact a Range Resource Inventory Survey.

This report discusses the progress to date. The results are tentative. Much of the progress to date is due to the very active cooperation of P. H. Heaton and J. L. Spatziani.

RANGE RESOURCE INVENTORY SURVEY

A range consists primarily of two parts - the (1) vegetative and (2) the physical parts. By the procedure developed and explained below, the two-parts are analyzed separately and are then combined into one over-all evaluation or rating in terms of carrying capacity of the range.

The cover is evaluated by current methods and the range condition and carrying capacity determined.

The physical part of the landscape is broken into (1) soils, (2) slopes, and (3) erosion.

Soils

Difference between soils often strongly influence the composition and vigor of vegetation. In this study comparisons between soils are based primarily on fertility, inherent erodibility, moisture infiltration, and moisture holding capacity. Other characteristics such as structure, pH, consistence, etc., are important in some instances. Differences between soils are expressed in values from 0 to 10 as shown in Table I. The value 10 represents the least desirable soil, while 0 represents the best soil for range plants. These values are used in Table IV as explained later. The values given the different soils in Table I are based only on field studies and are tentative. Preliminary laboratory tests to more precisely evaluate these field observations are discussed elsewhere in this report.

Table I. Comparative soil values

Soils from	Soil name	Values ^{1/}
Pikes Peak granite	(None as yet)	8
Granite-gneiss	"	7
Fountain sandstone	"	6
Biotite schist	"	4
Black Mt. basalt	"	3
Madison limestone	"	2

^{1/} Values refer to specific soils developed from a specific rock type or geologic formation and not to all soils developed from all granites or from all rocks of the same type.

The values in Table I are for soils developed in place or on bedrock. Soils developed from alluvium are not included. It should be strongly emphasized that these values are for specific soils developed from the named rocks in the Pike National Forest. As the work expands to other areas, new names and values will need be added to this list. The working list for a particular area should include only those soils in that area. No names have yet been given to the soils in Table I, but as soon as names are given them then such names should be used. To refer to all soils developed from granite as "granite soils" or from limestone as "limestone soils" would defeat the purpose of this table since there are great differences between soils developed from different granites. A similar comparison would be to call all grasses by one name.

Erosion

There are large differences between soils in their inherent ability to erode or to withstand abuse. But erosion is a reflection of more things than soil differences and the effect of slopes.

Erosion is land deterioration reflecting current land abuses. It is expressed as sheet and splash erosion, wind removals and all forms of gully development over landscapes which normally should not exhibit such conditions or should be affected only in minor degree. Potential erosiveness of the soil is included under the soil category in Table I. Only the actual degree of erosion in excess of normal soil losses is considered in Table II for both sheet and gully erosion.

Table II. Sheet and gully erosion values

Sheet erosion		:	Gully erosion ^{1/}	
Degree	Value	:	Degree	Value
None	0	:	<u>Occasional</u>	
			Shallow	1
Slight	2		Deep	3
			<u>Frequent</u>	
Moderate	5		Shallow	5
Severe	10		Deep	10

^{1/} Shallow gullies 2 feet deep; deep gullies >2 feet deep.

Values in Table II are on the basis of 0 to 10 with the large numbers reflecting the worse conditions. In cases where a landscape is affected by both sheet and gully erosion the values are added, e.g. the value 3 for occasional deep gullies and 5 for moderate sheet erosion are added to give the sum of 8 for a landscape of that character. These values are later used in Table IV. A total sum of 10 in this table removes the landscape from grazing use regardless of other physical conditions, including range condition.

Slopes

Slopes exert a strong influence on the degree of erosion and on the characteristics of the soil formed. They also affect grazing practices in that live-stock--especially cattle--have difficulty in grazing the steeper slopes.

The values given slopes in Table III have been tied in with the range condition class. This same procedure was used by Costello and Schwan (Conditions and Trends on Ponderosa Pine Ranges in Colorado, U. S. Forest Service, Mimeo.) and only slight alterations have been made here. Values in the table range from 0 to 20 because two factors--slopes and range condition--are included. These values are used in Table IV. All values of 20 remove the landscape from grazing use regardless of all other conditions. When certain soils are especially erosive, an added hazard exists and then special rules must be made. For example, soils developed from Pikes Peak granite should be totally removed from grazing when slopes exceed 40 percent.

Table III. Slope and range condition values

Percent slope	Range condition class					
	E ^{1/}	G	F	P	D	
0-5	0	0	4	6	20	
5-20	0	0	4	6	20	
20-40	4	6	10	16	20	
40-60	6	10	20	20	20	
60+	20	20	20	20	20	

^{1/}E=excellent, G=good, F=fair, P=poor, and D=depleted.

To arrive at one over-all adjustment figure the values obtained from Tables I, II, and III are added together. This gives a weighted sum expressing soils, erosion, slope, and range condition. In order to apply this value in terms of utilization cuts, Table IV has been developed to convert these ratings to percent adjustment figures. These are the final adjustment values for the physical conditions of the range and are superimposed on the grazing capacity values as determined by the cover survey. For example, suppose that a cover type had a grazing capacity of 1-A.U.M. for 10 acres and that the sum of the physical conditions fell between 14-15 indicating a 25 percent adjustment in Table IV. The 25 percent adjustment is applied to the 10-acre grazing capacity to give 12.5 acres per 1 A.U.M. Had the sum fallen between 0-11, the adjustment would have been 0 or none; had it fallen between 21-23, the adjustment would have been 75 percent or 17.5 acres per A.U.M.

The procedure could be applied in another way. Suppose that a specific 160-acre pasture would carry 32 A.U.M.'s on the basis of the several cover types present and suppose that the sum of the physical factors, being essentially uniform, fell between 12-13. The 12-percent adjustment indicated in Table IV would then reduce the 32 to 28 A.U.M.'s for the pasture.

Table IV. Final adjustment values

Sums between	Percent adjustment ^{1/}
0-11	0
12-13	12
14-15	25
16-18	37
19-20	50
21-23	75
24+	100

^{1/}Add values from Tables I, II, and III. The sums in left column correspond to the percent adjustment in right column.

The development of the above procedure has been held as simple as possible so that it could be used by students who lack training in field work. It has been and is being developed for use under the extensive conditions characteristic of low value range lands whose proper management should include an evaluation of the physical conditions as well as the cover type. If the principle of the procedure is correct--and we believe it is--then adjustments in the values of the tables can and should be made as data become available. The present values have been used and adjusted in the field, but more study is needed.

RESEARCH RESULTS

Soils

It is not enough to know that differences exist between soils, between kinds and degree of erosion, and between slopes. Such differences must be measured and given comparative values. A part of the field work is directed toward these ends.

Soil classification

Soils, like range forage, must be classified if organized use is to be made of the data. Preliminary work made it clear that the soil types and phases used on agriculture lands are too detailed for range land uses. The soil series or the family classification units appear to be more satisfactory. These less refined units are easy to recognize because of the usual close relationship between the rocks or geologic formations and the soils.

Three surface texture classes appear to be adequate. These are: (1) heavy textures or clay loams or clays; (2) medium textures or loams, silt loams and sandy loams; and (3) light textures or loamy sands, sands and gravel. Extremely stony areas are delineated by the cover survey, otherwise they can be ignored in most range lands.

The recognition of soil and textures is basic to the evaluation of the physical part of the landscape. It is important that a clear distinction be made between rocks and the soils which develop from them. Rocks weather to give soil parent materials. Soils developing from this weathered material may have little in common with the bedrock. There are great differences between granites, for example, and soils developed from them are distinctly different. Even soils developed from identical rocks under different climates are very different and these differences show up in the vegetation.

Transect studies

Preliminary data were needed to guide later investigations of the (1) differences between soils and (2) the relationship between soils and plant growth. Transect studies were used to obtain some of these data. Thirty-four transects of four different soil groups were made. Each was 100 paces long and was located up the slope, usually at right angles to the main drainage way. Soils were studied in the middle and at each end of the transect. Usually soil samples were taken for later analysis. Cover data such as type, density, species, vigor, litter, and range condition were recorded by Heaton or

Spatziani. A number of leads came out of these studies, although the data are only indicative of trends because it was not possible due to bad weather to complete a sufficient number of transects.

Cover density and erosion

The relation between percent of cover and degree of erosion is shown in Table V for the four groups of soils studied.

Table V. Relationship between degrees of erosion on different soils to total and grass densities

Soils developed from	No. of : samples or : transects	Erosion ^{1/}	Percent cover density	
			Total	Grass
Black Mt. Basalt	5	O to S-	48	34
	3	S	40	25
	3	M	33	18
	3	Se	25	14
Biotite Schist	1	S	43	21
Pikes Peak Granite	2	M	--	22
Granite Gneiss	4	S	33	23
	1	M	24	14

^{1/} Erosion: S - slight, M - moderate, Se - severe.

The total and grass densities are average figures based on the total number of samples or transects. A good correlation appears to exist between both total and grass densities and the erosion classes. In each case the cover became less dense as the severity of erosion increased. There were not enough samples to make good comparisons between soils. These data support field observations that eroded soils are poor producers of forage.

Depth of surface soils

The transect studies brought out a good correlation between depth of surface soil and range condition and total and grass densities. The data are shown in Table VI.

Table VI. Relation of depth of surface soil to range condition, total and grass densities

Soils developed from	Thickness of	Range	Percent cover density		Grass
	surface	condition	Total	Grass	vigor
	soil				
	(inches)	<u>1/</u>			<u>2/</u>
Black Mt. basalt	12	E	41	32	VH
	10	E	53	39	VH
	9	G	50	35	VH
	6	G	50	35	H
	6	G	45	31	H
	11	F +	45	28	H
	9	F	45	23	M
	6	F	40	22	M
	6	F	31	22	M
	6	F	35	--	M
	5	P +	30	20	M
	5	P	35	16	L
	4	P	25	16	L
	4	P	25	12	L
	4	P	20	12	VL
Pikes Peak Granite	5	F +	--	28	M +
	4	P	--	16	M
Biotite Schist	7	P	43	21	F
Granite Gneiss	11	G	42	31	M +
	5	P +	30	18	M
	12	F	35	26	M
	4	P	25	18	M
	1	P	24	14	L

1/ E - excellent, G - good, F - fair, P - poor.

2/ V - very, H - high, M - medium, F - fair, L - low.

These data emphasize the effect of a good thickness of surface soil on growing plants--their vigor and density. If this relationship is supported by later investigations, then thickness of surface soil may be a good criteria for the ranger and the range surveyor to use in substantiating other observations.

Other soil characteristics

Relationship between range cover and other soil characteristics such as consistence, texture, color, and pH were not brought out by the transect study. This is probably due to the type of study or to insufficient observations.

Observations other than those of the transects indicate important differences between soils and the cover. The average number of grass species from all transects under all range conditions growing on soils developed from different rocks were as follows: limestone 6, biotite schist 6, Black Mt. basalt 4, and granite gneiss 3. Shrub numbers were highest on soils from schist, then andesite, followed by limestone, and then gneiss. Grasses seem to grow especially well on soils developed from limestone and basalt. Shrubs, especially mountainmahogany, grow especially well on limestone soils. Ponderosa will grow on limestone, but is often excluded or at least is absent from large shrub-covered areas.

Aggregate stability of different soils

Many samples of surface soils were collected from the transect studies for laboratory analyses. One of the laboratory studies was to determine the water stability of the surface soil aggregates of the different soils under different cover types.

The air-dry samples were put through a quarter-inch sieve to remove rocks and as many roots as possible. Duplicate samples of 20 grams each were placed on a 60-mesh sieve (0.25 mm.) and raised and lowered in a water bath 30 times per minute for 10 minutes. The residue on the sieve was then oven-dried at 105° F. and weighed. The percent aggregation was made on the basis of the air-dry sample. The results of this analysis are shown in Table VII under the column headed "Apparent aggregation."

Table VII. Percent of water stable aggregates of different soils under different range conditions

Transect No.	Cover	Soil	Apparent aggregation ^{1/}			Real aggregation ^{2/}		
			T ^{3/}	M	B	T	M	B
			Percent			Percent		
<u>Excellent range condition</u>								
39 V ^{4/}	Meadow	Basalt	57.8	58.0	62.5	18.4	18.5	29.0
37 V	Meadow	Basalt	66.7	63.5	61.0	18.2	12.0	11.5
20	Aspen	Basalt	66.7	59.0	61.0	32.0	28.2	32.2
<u>Good range condition</u>								
35	Meadow	Basalt	49.2	58.5	54.2	11.6	11.5	12.7
18 V	Meadow	Basalt	53.0	52.5	57.5	26.6	23.9	21.2
17	Meadow	Basalt	75.0	65.5	63.0	22.0	24.7	19.7
50 V	Meadow	Gneiss	73.9	71.5	69.0	24.4	15.5	23.5
21	Aspen	Basalt	71.5	64.7	64.7	47.5	39.9	34.0
<u>Fair range condition</u>								
22	Meadow	Basalt	44.7	58.2	50.5	12.4	21.5	16.1
24	Meadow	Basalt	55.5	57.5	66.2	23.7	18.7	32.0
36	Meadow	Basalt	48.0	59.2	55.8	15.2	13.2	13.4
19	Meadow	Basalt	58.7	60.7	54.5	23.5	28.4	25.2
29 V	Meadow	Gneiss	68.5	66.5	68.0	16.5	12.4	17.8
<u>Poor range condition</u>								
25	Meadow	Basalt	52.3	49.1	61.0	23.8	22.4	41.0
26	Meadow	Basalt	61.7	53.0	55.5	13.4	11.4	15.5
23	Meadow	Basalt	54.5	64.2	55.8	17.7	21.9	11.5
28	Meadow	Gneiss	60.5	58.2	63.5	6.0	8.0	7.8
30	Meadow	Gneiss	62.5	60.7	62.9	12.5	10.4	10.1

^{1/}The weight of the material remaining on the 60-mesh screen after the oscillation-in-a-water-bath procedure. Called "apparent aggregation" because it contained some sand and gravel as individual particles.

^{2/}"Real aggregation" obtained by subtracting weight of sand and gravel from the aggregates and using the remainder as material really aggregated in granules 0.25 mm.

^{3/}T, M, and B refer to the sampling sites at the top, middle, and bottom of the transect: samples were 50 paces apart (250 feet).

^{4/}Virgin soil.

Since many of the samples contained a high percentage of sand and gravel it would appear that the "apparent aggregation" percentages are high. To determine what effect sand and gravel might have on these percentages, the aggregates were dispersed and the material washed through the 60-mesh sieves. The sands and gravels remaining on the sieves were dried and weighed. The weight of this material was added to the weight of the soil which passed through the 60-mesh screen in the first operation. It was assumed that this gave the total amount of material which played no part in aggregation--that smaller than 60 mesh and the sand and gravel larger than 60 mesh. The aggregation percent computed on this basis is shown in Table VII under the column "Real aggregation." These figures are very low in comparison with the apparent aggregation figures. Their value as an expression of the true aggregation is open to question since undoubtedly much of the finer sands which were screened out were incorporated as a part of the original aggregates. The true aggregation percent probably lies somewhere between the figures in these two columns.

Using the real aggregation percentages, the following points can be made:

1. The highest percent of aggregation was obtained under aspen on soils from basalt (samples 20 and 21).
2. The lowest percent of aggregation occurred under a meadow on soils developed from granite gneiss (samples 28 and 30).
3. Samples from virgin soils developed from granite gneiss were about as well aggregated as soils from basalt (samples 50 and 29). This suggests that the structure from granite gneiss soils is more readily destroyed by abuse than in the case of soils from basalt.
4. Range condition appears to have had little effect on aggregation. This is an expected result due to the limited number of samples taken.
5. Twenty-five, or about half, of the 54 samples had aggregation percentages falling between 10 and 18 percent. The remainder were scattered between 6 and 47.5 percent.
6. Virgin samples of soils from basalt appeared to be no better aggregated than other similar samples (samples 39, 37, and 18).

One possible reason for the heterogeneity of these results may be the manner in which the samples were taken. The surface 4 or 5 inches were taken and mixed together. The laboratory sample was taken from this by quartering. It might have been better to have taken only the surface 1 inch of soil for this test--a procedure which will be tried.

The percentage of aggregation should be an expression of the soil's ability to absorb and hold water, and to withstand or resist the factors which lead to erosion. It should also be an expression of the amount of organic matter in the soil.

INDICATORS OF RANGE AND SOIL CONDITIONS

A number of studies were made of the relation between range cover and soils in addition to those reported above.

Pedestal cycle

Soil pedestals held in place by a coping of grass are common in range lands. It was observed that their numbers increased and their distinctness of form became more apparent as the severity of surface erosion increased or as the range condition deteriorated. In range surveys, as conducted before the changes proposed in this report, pedestaling of bunchgrass was accepted as indicating the loss of surface soil amounting to the height of the pedestals. These studies show that this is not always true--that the losses may actually be greater.

A study of pedestals led to their being classed in four categories on the distinctness of their shape or form. These four classes or stages are defined and illustrated in Figure 1. These four stages occur on all ranges in all conditions of vigor. They occur where the surface soil is little eroded or where the soil has been removed down to the raw parent material. The four stages repeat themselves over and over--are cyclic. Sites are rare where no Stage I pedestals occur although on depleted range or where surface soils are eroding badly, Stages III and IV are the most numerous. There is no way of determining from the pedestals on the ground whether it is the first or fifth cycle for the site, but it can be determined by examining the thickness of the surface soil and by having a knowledge of what should have been the original thickness.

Data were collected on pedestals while the transect studies were in progress. These data (Table VIII) consist both of actual counts and of estimates of the different stages.

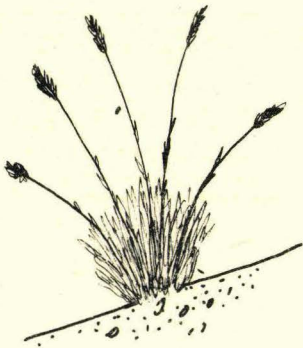
Table VIII. The relationship between pedestaling cycle stage, range condition and depth of surface soils

Thickness of surface soil Inches	Range condition	Pedestal types and percent of each			
		1	2	3	4
9	E	98	2		
13	G +	100			
9	G	90	10		
6	G	90	10		
6	G	70	20	6	4
11	F +	95	5		
9	F	70	20	10	
6	F	66	20	10	3
6	F	10	45	40	5
6	F	10	45	26	10
5	P +	3	50	36	11
4	P		48	38	13
5	P	14	22	50	14
4	P	17	22	60	3

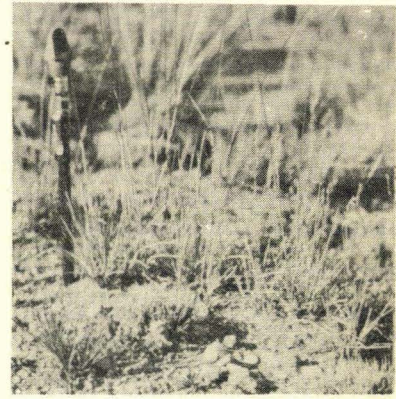
1/E - excellent, G - good, F - fair, P - poor.

Figure 1.--The Four Stages of the Pedestaling Cycle Occurring in Bunchgrass Range.

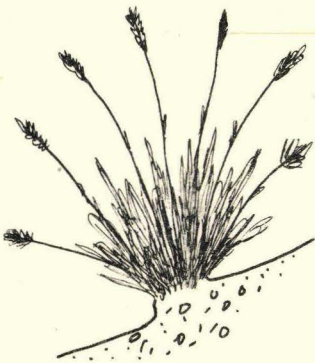
STAGE I



Plant crown on a level or near level with surface of soil. No pedestal or raised condition.



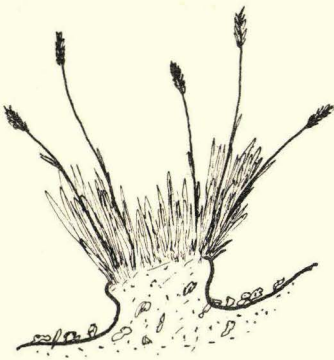
STAGE II



Plant crown above level of soil surface around part of its perimeter. This breaking away tends to occur on the down-hill side of clumps on slopes even of low gradient, although it may occur on the up-hill side. Part of plant crown remains even with the soil surface.



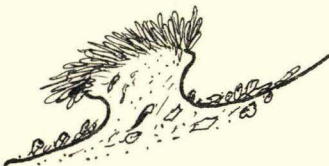
STAGE III



The entire plant sets on a soil pedestal above the adjacent surface on all sides. Pedestal sides are commonly raw in degrading ranges and covered with litter on recovering ranges. The soil between pedestals is bare or nearly so on degrading ranges and litter covered to a certain extent on recovering ranges. These pedestals may often stand as much as 4 to 6 inches high



STAGE IV



The grass on top of the pedestal is dead or nearly so and the pedestal is disintegrating. The dead stems lean down over the sides and often break off in large pieces. On steep slopes the dead stems lean downhill and soil may be creeping over the old pedestal from above; on more level areas the dead stems disintegrate in all directions.



The data in Table VIII show a good correlation between range condition, thickness of surface soil, and the percentage of the different stages of pedestals. The table does not include data from soils where all the surface has been eroded away, but where pedestals are still prominent in the raw parent soils materials.

These data are of practical value to both the range surveyor and to the ranger. They may serve as an additional check on range condition to supplement density counts and composition. When sufficient data are available it may be possible to establish percentage limits of the different stages to correlate with range condition. For example, the data for Stage IV indicates a poor range condition when the percentages fall between 10 and 15.

Pedestals and soil moisture

The study of pedestals led to the discovery of another relationship of direct importance to range management. Following a 4-inch snow while transect studies were being made in the Eagle Rock allotment, Heaton noted a peculiar distribution of soil moisture beneath pedestals of the III and IV stages. Moisture had penetrated the dry soil 4 to 5 inches in the bare areas between pedestals but within the pedestal the dry soil "coned" up very distinctly. This relationship is shown in the photo and drawings of Figure 2. Other observations showed a continued recurrence of this moisture distribution. It did not occur in the I and II Stages. Neither did it occur in later observations following heavy rains or deep snows which melted slowly. The tentative conclusion is that the center die back of bunchgrass clumps occurs during the III pedestaling stage and that it is due in part at least to a lack of moisture. The pedestal is saturated by abundant moisture but much of the annual precipitation comes as light showers which are ineffective. The plant actually suffers from drought and we have "little deserts" in a range where the III Stage of pedestaling occurs. More studies are planned to check on these relationships.

Pavement

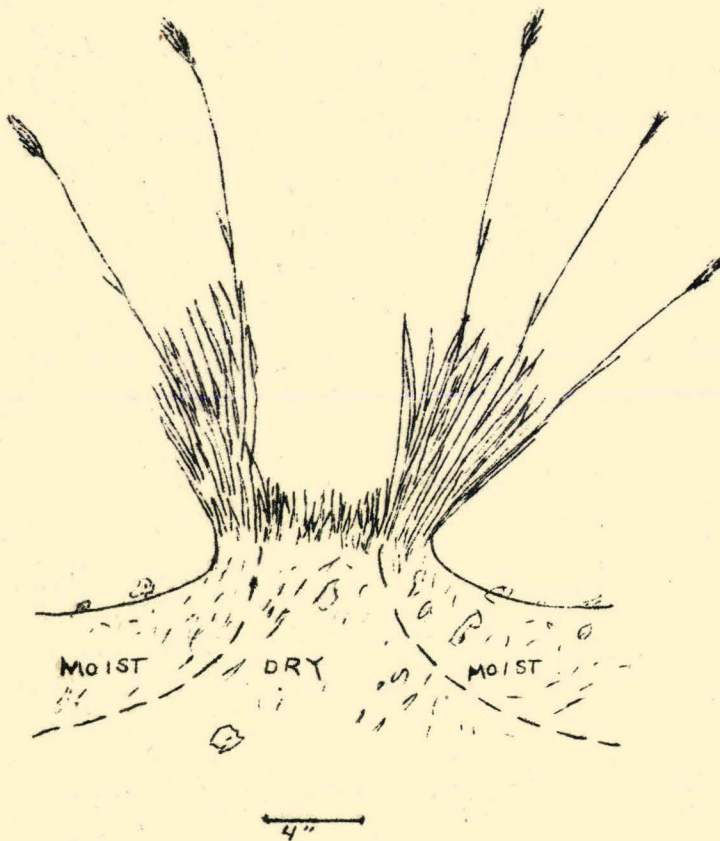
Gravel pavements have often been used as an indicator of surface erosion. Pavements do indicate that erosion has or is occurring but again as in the case of pedestals they do not tell how much surface soil has been lost. A pavement merely indicates that erosion is taking place. It must be used with caution since its absence does not mean that erosion is not occurring or that it is not already severe. Many soils do not leave a pavement residue as their surface erodes. Where pavements do form they often become thick enough to afford a degree of protection to the surface. In such cases they tend to act like litter in preventing or slowing down surface erosion. (It is not recommended that range lands be allowed to erode until a gravel pavement protects them from further losses.)

Soil losses

Since neither pedestals nor the presence of a pavement can be accepted as a measure of the amount of erosional soil loss such evidence must be obtained elsewhere. "Relics" of the original undisturbed soil where erosion has been little accelerated by man's activities are used. Such areas are few and usually small. They occur in localities remote from water or are otherwise

Figure 2.--Distribution of soil moisture beneath pedestaled plants following a light snow

Distribution of moisture beneath straight stem muhly in the third pedestal stage. Eagle Rock allotment, Pike National Forest, Oct. 8, 1946. Photograph by Phil Heaton.



Distribution of dry and moist soil beneath mountain muhly in the third pedestal stage. Above the cone of dry soil the plants are dead. Sketch to scale and across a 23% slope. Saddle Mountain, Pike National Forest, Oct. 9, 1946.

inaccessible. Enough of such sites were located and studies on the Pike in 1946 to support the conclusion that the surface soils (A horizon) on Pike grass lands originally ranged in thickness from 10 to 15 inches. The present thickness is from 4 to 8 inches. This method of estimating the amount of soil losses from a large area has obvious weaknesses. But the deductive method based upon careful consideration of all available pedologic evidence is the only known approach if estimates of such losses are required.

OTHER OBSERVATIONS

Livestock tend to congregate in meadows, creek bottoms, etc. As a result these areas are often denuded, gullied, and otherwise in bad condition. However, much of this deterioration is primarily due to denuded and eroding uplands back from the creek bottoms. It is on such areas that the destructive run-off originates. Even if totally protected, the stream bottoms could not withstand the increased volume of water which pours over them from the overgrazed uplands. The real problem seems to be in keeping the rainfall on the uplands and away from the valley bottoms.

Soils on alluvial fans and flood plains are usually the best forage producing soils because of their good physical condition and because they have a continuous moisture supply. In the Eagle Rock allotment, the range condition is as depleted on these favorable sites as on the uplands. Thus, it would seem that when a range is in an extreme stage of depletion soil differences will have little effect on the existing vegetation.

On depleted ranges lichens and club mosses cover a high percentage of the surface. Their system of fine roots (rhizoids) is very dense and undoubtedly they intercept much rainfall before it can be used by grasses. These plants are especially prominent on soils developed from granites. They do not seem to occur in important numbers on soils developed from other rocks. Any reseeding work on areas infested with club moss must include its elimination.

GEOLOGY

Because of their influence on soil characteristics, geologic formations and rock types are important in a study of range soils.

Nearly all the soils on the Pike strongly reflect the characteristics of the rocks from which they develop. This influence is in part due to erosion which rapidly removes the surface soils to constantly expose the rawer materials below. Soils with widely different characteristics develop in the same vegetative zone because of these parent rock differences. Soil colors, pH, fertility, structure, and potential erodibility are the characteristics most noticeably influenced by parent materials. Soils developed from andesite, basalt, and biotite schist have an open granular structure and black loam or clay loam surface soils. They have a pH of 7.0 or above, produce a good dense cover of grasses and are fairly erosion resistant. Soils developed from limestone are a little superior to the above group in all ways. Soils

developed from Pikes Peak granite, granite gneiss, and from the Fountain arkose erode rapidly, are light brown in color, infertile, and have coarse sandy or gravelly textures.

Soils developed from Pikes Peak granite are so erosive that it is well to point out some of the causes for their behaviors. These causes are;

1. Pikes Peak granite cooled as a mass deep below the surface thus giving rise to exceptionally large distinct crystals.
2. Pikes Peak granite is composed of quartz, orthoclase, and biotite. The biotite forms lines of weakness between the orthoclase crystals permitting the rock mass to disintegrate readily.
3. These gravels-quartz and orthoclase-with their sharp angles make excellent erosion chisels as they moved down-slope by run-off.
4. The rapid regional erosion does not permit the surface soils to remain in place long enough to break the coarse orthoclase gravels down into fine materials, thus surface textures remain angular and erosive when moved.
5. When orthoclase weathers the end product is kaolinite clay. This clay is one of the least erosion resistant types of the soil clay minerals.
6. When the coarse gravels are deposited in stream channels they do not consolidate as fined textured sediments do. They remain loose and are moved readily down stream and away from their place of origin. This explains in part why few stream beds are choked with gravel.

It should not be inferred from this general discussion that only one soil series develops from a particular kind of parent rock. Differences between soils developed from the same rock are often greater than those developed from different rocks.

GEOMORPHOLOGY

Observations were made of the different land forms and their position in the erosion cycle. The most distressing occurrence is the rapid rejuvenation of the erosion cycle throughout the entire forest. This gully cutting and grade lowering appears to be about as rapid in the early-old age relief of the Guffey country south of South Park as in the mature Rampart and Tarryall regions. Because of the mature relief the course of this stream rejuvenation will be harder to stop or check and more disastrous to watershed values in the mature relief areas than in the old age relief areas. The acreage of the latter land form type is small in comparison to the Pike's total area.

The geomorphologic story in the Trout Creek drainage is especially interesting since at least three sets of alluvial fans have been produced. Rock differences have given rise to different types of streams. There, too, the effect of a vegetative cover upon the forwarding of the erosional cycle is well illustrated.

Some additional study is planned for Trout Creek to further clarify the part of land-forms in the solution of the Pike's problems. A generalized grouping of the land forms for the entire forest is planned together with interpretations for management plans.

The type of land form and its position in the erosion cycle may be more fundamental in determining the proper use of a landscape than either soils or cover. Usually the three--land forms, soils, and cover--are all closely related so studies of one will support the finding from studies of the other two.

Sections of the Pike have distinctly different types of relief and as a result should be managed differently. The Eagle Rock territory has a relief distinct from that of the Guffey country and both differ from the Rampart Range type of relief.

Rejuvenation of the erosion cycle is most noticeable as a result of the extensive systems of new gullies. Their sides are steep and cave in each year. They elongate headward and their channels are constantly deepening. In many places they have chewed away a large percent of the old valley bottoms, changing them from wet to dry meadows.

Both gully and surface erosion will be harder to slow down or check in an area having a mature type of relief such as the Front Range country than where the relief is of the old-age type as in the Guffey country. The broad type of relief determines to a certain extent the kind of use that should be placed over a landscape.

FUTURE PLANS

Work will be continued on the study of pedestals and their influence on moisture distribution in the soil.

An extensive and intensive study of types, forms, and significance of gully erosion is planned for the Pike.

A study is planned for meadow soils--the effects of gullying, debris deposition, soil changes, etc.--and the extent of these changes.

The study of the effects of land forms and the influence of geology on land management will be continued.

The study of the best system of soil classification to use for range lands will be continued.

Most actively pursued will be the range-soil study in which the cover and physical factors are tied together by the range resource survey. The procedures given at the beginning of this report will be thoroughly tested and needed adjustments made.